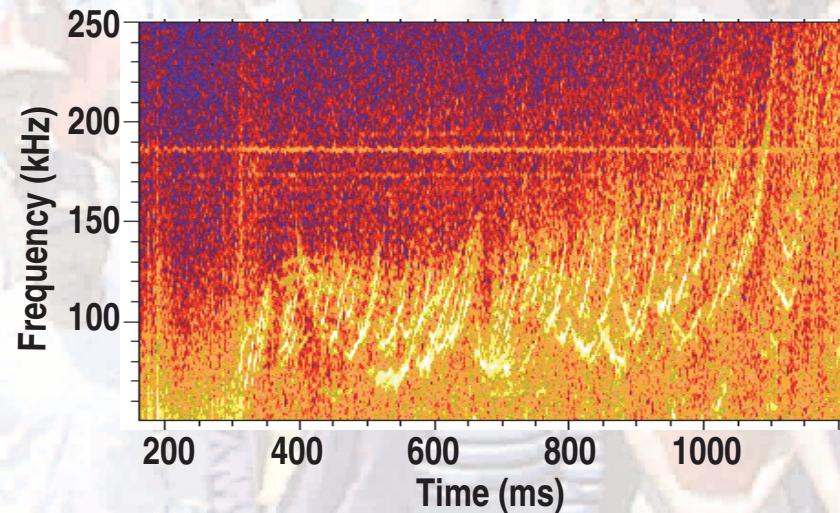


University Research and DIII-D

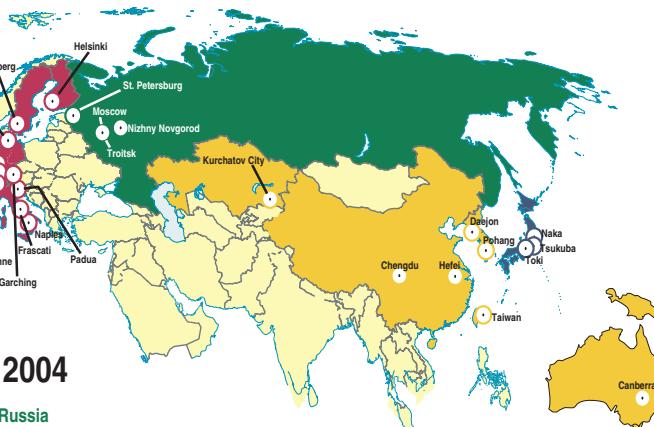
by
W.W. Heidbrink

Presented at
Office of Fusion Energy Science
FY08 Budget Planning Meeting
Washington, DC

March 14–15, 2006



DIII-D is a Large, International Program



Active Collaborations 2004

US Labs

ANL (Argonne, IL)
LANL (Los Alamos, NM)
LBNL (Berkeley, CA)
LLNL (Livermore, CA)
ORNL (Oak Ridge, TN)
PPPL (Princeton, NJ)
SNL (Sandia, NM)

Industries

Calabasas Creek (CA)
CompX (Del Mar, CA)
CPI (Palo Alto, CA)
Digital Finetec (Ventura, CA)
DRS (Dallas, TX)
DTI (Bedford, MA)
FAR Tech (San Diego, CA)
IOS (Torrance, CA)
Lodestar (Boulder, CO)
SAIC (La Jolla, CA)
Spinner (Germany)
Tech-X (Boulder, CO)
Thermacore (Lancaster, PA)
Tomlab (Willow Creek, CA)
TSI Research (Solana Beach, CA)

US Universities

Auburn (Auburn, Alabama)
Colorado School of Mines (Golden, CO)
Columbia (New York, NY)
Georgia Tech (Atlanta, GA)
Hampton (Hampton, VA)
Lehigh (Bethlehem, PA)
Maryland (College Park, MD)
Mesa College (San Diego, CA)
MIT (Boston, MA)
Palomar (San Marcos, CA)
New York U. (New York, NY)
SDSU (San Diego, CA)
Texas (Austin, TX)
UCB (Berkeley, CA)
UCI (Irvine, CA)
UCLA (Los Angeles, CA)
UCSD (San Diego, CA)
U. New Mexico (Albuquerque, NM)
U. Rochester (NY)
U. Utah (Salt Lake City, UT)
Washington (Seattle, WA)
Wisconsin (Madison, WI)

Russia

Ioffe (St. Petersburg)
Keldysh (Udmurtia, Moscow)
Kurchatov (Moscow)
Moscow State (Moscow)
St. Petersburg State Poly (St. Petersburg)
Triniti (Troitsk)
Inst. of Applied Physics (Nizhny Novgorod)

European Community

Cadarache (St. Paul-lez, Durance, France)
Chalmers U. (Goteborg, Sweden)
CFN-IST (Lisbon, Portugal)
CIEMAT (Madrid, Spain)
Consortia RFX (Padua, Italy)
Culham (Culham, Oxfordshire, England)
EFDA-NET (Garching, Germany)
Frascati (Frascati, Lazio, Italy)
FOM (Utrecht, The Netherlands)
Helsinki U. (Helsinki, Finland)
IPF-CNR (Italy)
IPP (Garching, Greifswald, Germany)
ITER (Garching, Germany)
JET-EFDA (Oxfordshire, England)
KFA (Julich, Germany)
Kharkov IPT, (Ukraine)
Lausanne (Lausanne, Switzerland)
IPP (Greifswald, Germany)
RFX (Padova, Italy)
U. Dusseldorf (Germany)
U. Naples (Italy)
U. Padova (Italy)
U. Strathclyde (Glasgow, Scotland)

- 90 institutions participate
- 515 active users
- 119 GA
— 396 others
- 317 scientific authors (2004)
— 577 cumulative
- 1082 visits to GA (2000–2004)
- Students and faculty have been from
 - 65 universities
 - 28 states

BROAD INTEREST IS SHOWN IN THE 586 RESEARCH PROPOSALS FOR CY06–07

FOREIGN

CEA Cadarache 6	FSZ Julich 7
EFDA-CSU 8	IPP Garching 7
ERM-KMS 1	JAERI 1
Euratom 2	U. Toronto 7
UKAEA 11	

Total: 50

DOMESTIC

Columbia 22	ORNL 21
FarTech 4	PPPL 66
Georgia Tech 2	SNL 7
GA 276	UCI 6
Lehigh 2	UCLA 30
LLNL 44	UCSD 30
MIT 3	U. Texas 4
ORISE 4	U. Wisconsin 15

Total: 536

Major US University Programs on DIII-D

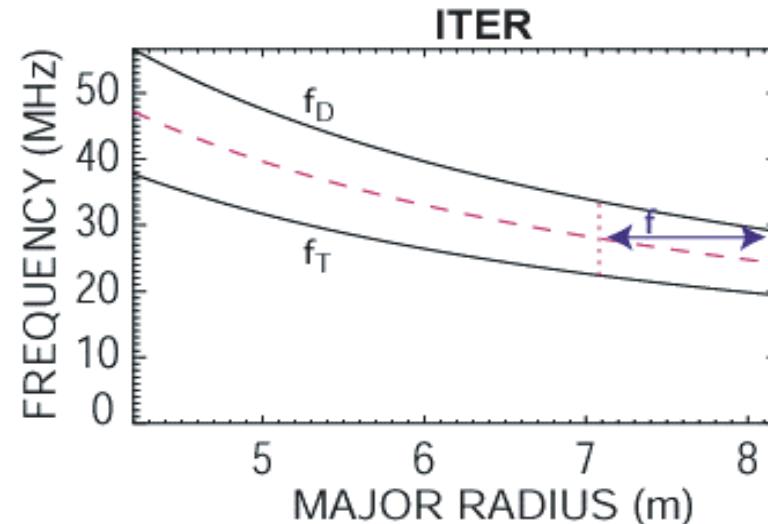
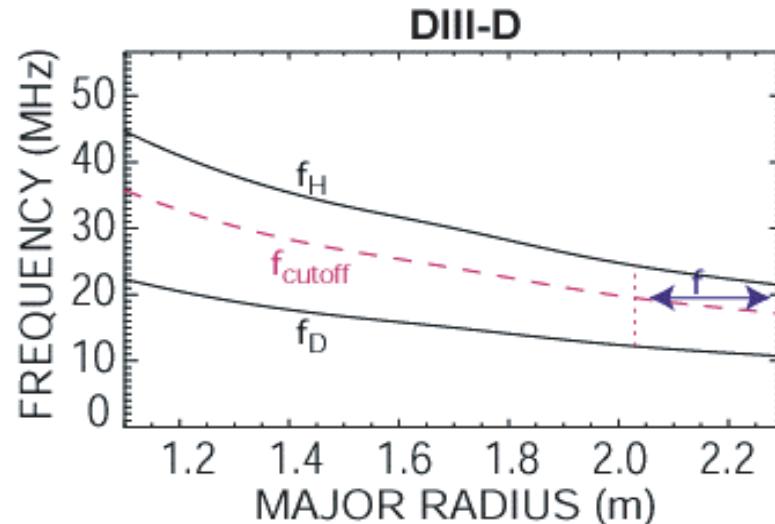
- Columbia U. Resistive wall mode research
- Georgia Tech Pedestal and edge physics
- MIT Phase contrast imaging diagnostic
- Lehigh Transport studies
- UC-Irvine Energetic particle physics
- UCLA Turbulence measurements, transport
- UCSD Edge turbulence measurements, disruptions
- U. Maryland EC diagnostics
- U. Texas ECE measurements, confinement physics
- U. Toronto Divertor physics
- U. Wisconsin BES, turbulence and transport

Major University Programs on DIII-D

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Species Mix Diagnostic Concept Demonstrated

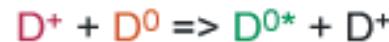
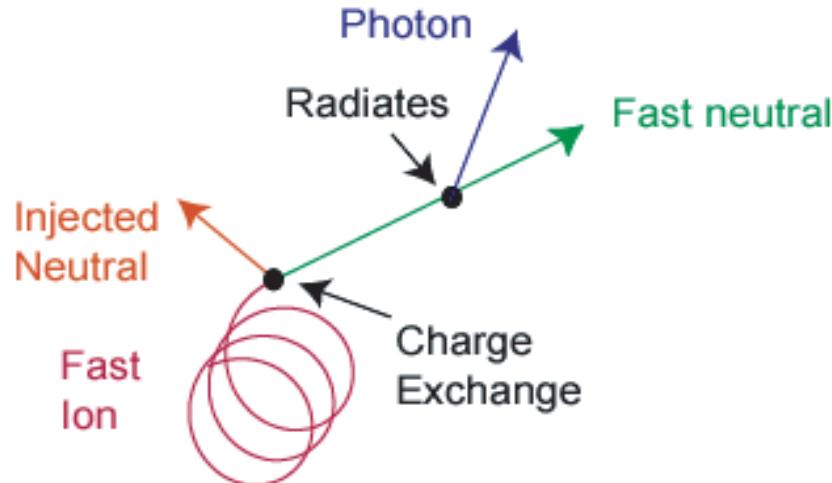


George Watson's Ph.D. thesis: "Ion Species Mix Measurements using Radio Frequency Waves"

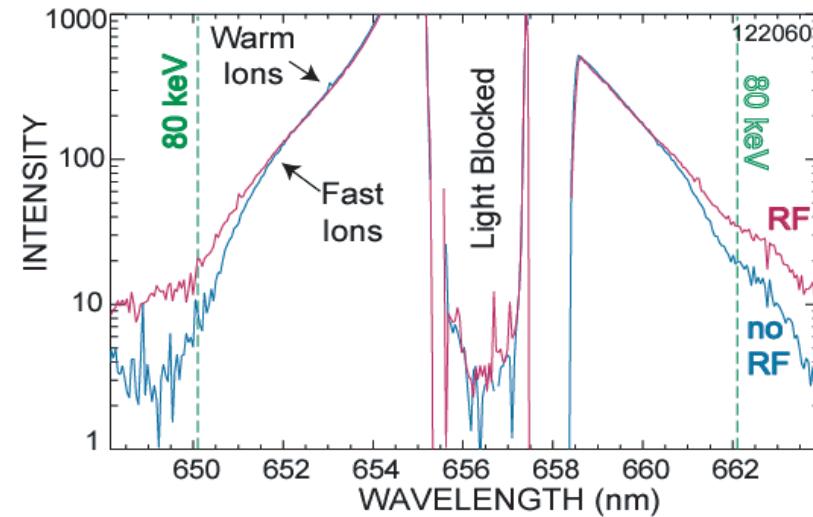
- Radius of the ion-ion hybrid cutoff layer depends on species mix
- Reflect waves off cutoff to measure hydrogen (DIII-D) or tritium (ITER) concentration
- Watson successfully measured hydrogen concentration
- Further tests of antenna design & antenna-plasma spacing are needed
- JET experiments in next D-T campaign are planned

Use D_α to Measure Fast-ion Energy and Profile

Yadong Luo's Ph.D. thesis: "Measurements of the fast-ion distribution function using Balmer-alpha light"

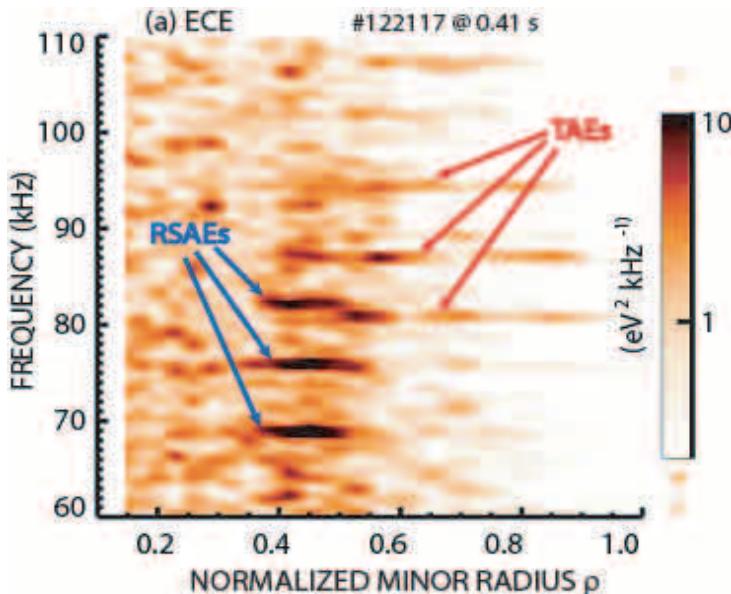


- Charge-Exchange Recombination Spectroscopy of fast hydrogen
- Exploit Doppler shift to avoid bright interference
- Resolution: 10 keV, 5 cm, 1 ms.

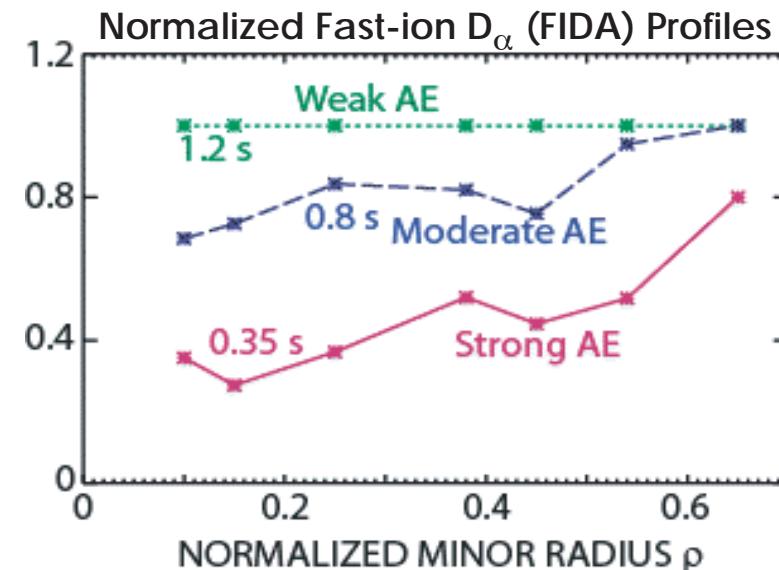


New Fluctuation and Fast-ion Diagnostics → Understand Fast-ion Transport by Alfvén modes

Mike VanZeeland's postdoc



Yadong Luo's thesis

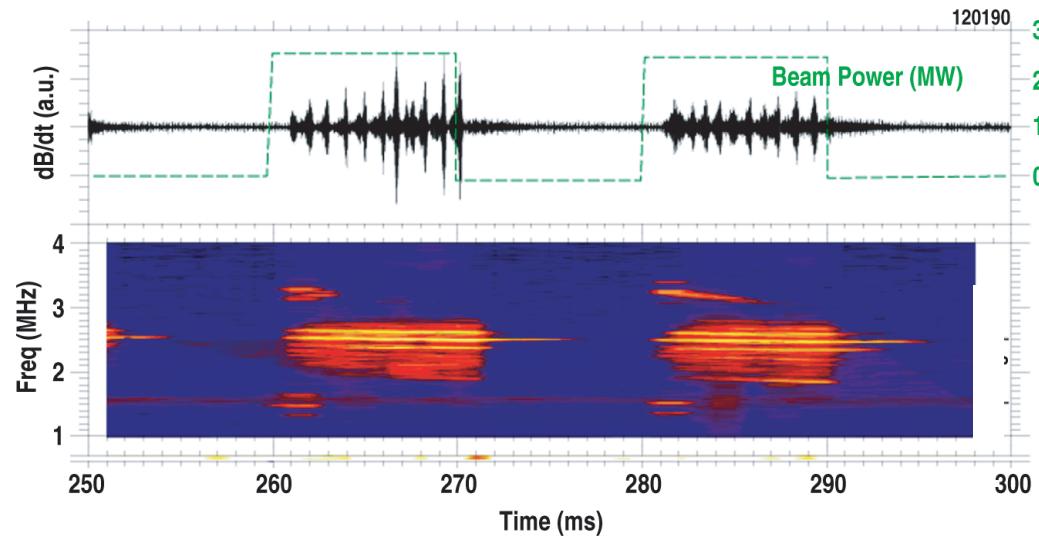


- Wisconsin, UCLA, Texas, and MIT groups measure Alfvén eigenmodes
- Predict AEs & compare

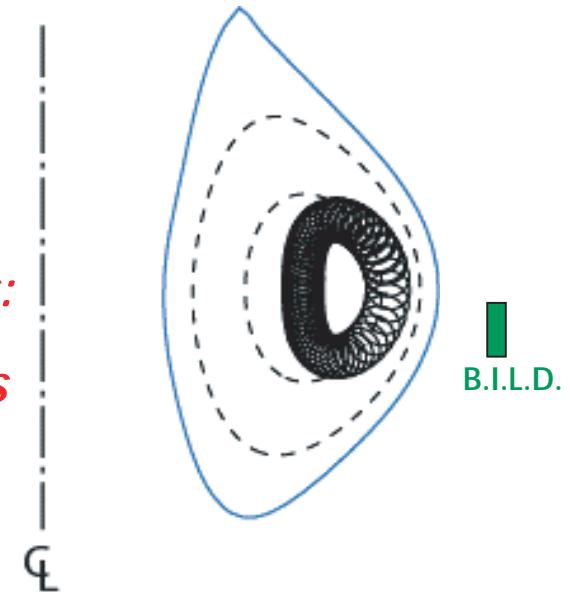
- 12-channel dedicated FIDA diagnostic planned for 2007
- Calculate fast-ion transport in validated wave fields
- New Ph.D project

Undergraduate Projects Draw Outstanding Talent

James Kim's Senior Thesis: Spectrum of Compressional Alfvén Eigenmodes

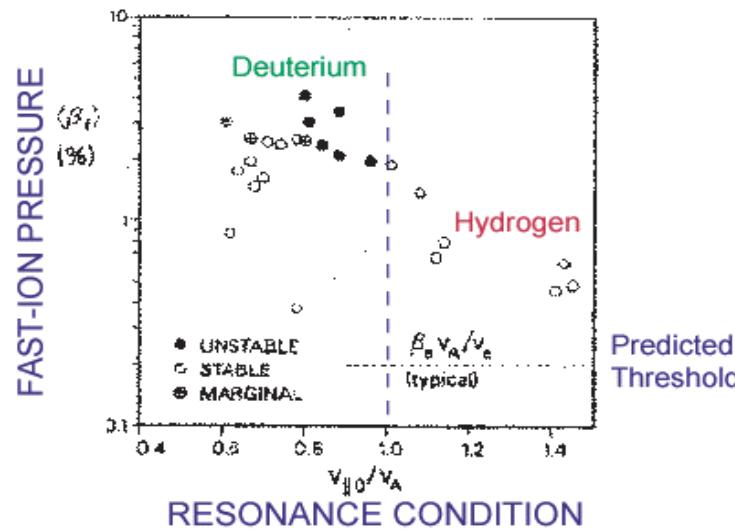


*Lorei Pickering's Senior Thesis:
Understanding Beam-ion Loss
Detector Signals*



Faculty Influence the Scientific Community

TAE Colloquium: "The experiment didn't work quite like the theory"



"For the theoretical discovery and experimental verification of toroidicity-induced Alfvén eigenmodes"

- Inform colleagues
- Recruit graduate students into plasma physics
- Educate undergraduates about fusion
- Develop scientific literacy in schools & community

DIII-D's Scientific Productivity Could Support More PH.D. Theses and Entry Post-Doc Research

- Historically – 65 universities from 28 states
- 20 U.S. universities participate in DIII-D now
- DIII-D has trained
 - 31 graduate students
 - 26 post doctoral fellows
- 15 current Ph.D thesis students
- Post-Doc's work led to significant contribution (e.g. IAEA 2004)
 - W.M. Solomon (PPPL)
 - M. Groth (LLNL)
 - H. Reimerdes (Columbia)
 - E.M. Hollman (UCSD)



- DIII-D can train more young researchers for ITER and the fusion program
 - An incremental budget request is made for 7 graduate students and 3 postdocs

Current Ph.D Thesis Students on DIII-D

Ongoing Theses

1. **A. McLean** - *U. Toronto* – Plasma Surface Interactions, Chemical Sputtering
2. **J. Dorris** – *MIT* – Phase Contrast Imaging
3. **N. Antoniuk-Pablant** – *UCSD* – Spectroscopy of Dalpha region for main ion Ti and internal B field
4. **Y. Luo** – *UCI* - Measurement of fast ion profiles using D-alpha spectra
5. **O. Katsuro-Hopkins** - *Columbia U.* - Optimized Feedback Control System Modeling
6. **M. Schlossberg** - *Wisconsin* - Determination of Turbulence Velocity and Heat Flux Dynamics near the LH Transition
7. **M. Shafer** - *Wisconsin* – Nonlinear Turbulence Dynamics during Internal Transport Barrier Formation
8. **Z. Friis** – *Georgia Tech* – Thermal Instabilities in Tokamaks
9. **S. Harrison** – *Wisconsin* – Plasma Surface Interaction Diagnostics
10. **Y-S Park** – *Seoul National University* – Neoclassical Tearing Mode Detection and Control
11. **D. Pretty** – *Australia National University* – Stochastic Edge Magnetic Fields
12. **A. White** – *UCLA* - Electron temperature fluctuation measurements on DIII-D via correlation ECE
13. **C. Estrada-Mila** - *UCSD* - Turbulent Transport Simulations
14. **E. Nardon** - *CEA* - ELM Control by Stochastic Edge Fields
15. **D. Elder** - *U. Toronto* - OEDGE modeling of the DIII-D 13C methane experiments
16. **Y. Mu** - *U. Toronto* - OEDGE modeling of DIII-D DIMES experiments

Theses Under Consideration

17. **M. Lanctot** - *Columbia* - Advanced Algorithms for RWM Feedback Control

